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W. A. WITHERS, A. M., ACTING DIRECTOR

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BAKING POWDERS

ON SALE IN NORTH CAROLINA.

W. A. WITHERS AND J. A. BIZZELL.

RALEIGH, N. C.

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*BAKING POWDERS ON SALE IN NORTH CAROLINA.

W. A. WITHERS, A. M., CHEMIST,
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AERATION OF BREAD

The greater quantity of bread consumed by man is leavened, *i. e.*, it is soft and spongy. The leavening process consists simply in the generation of carbonic acid gas within the dough. On expanding, through natural pressure, or under the influence of heat, a porous, spongy condition is produced in the dough, and on baking this condition remains fixed.

The methods for the production of carbonic acid gas in bread-making belong to the following three classes: (1.) Introduction into the dough of previously prepared gas. (2.) Fermentation, *i. e.*, generation of gas within the dough through the presence and activity of certain germs. (3.) Generation of gas within the dough by use of certain chemical agents. Baking powders are included in the third class.

The first of these methods is only of historical importance. It has not proven of practical application, so will not be spoken of further.

The second method provides for the generation of carbonic acid gas through the process of fermentation. Fermentation depends on the activity of certain germs, which are usually added in the form of yeast. The gas is formed from the natural constituents of the flour, hence nothing is introduced into the bread which would in the slightest degree be unwholesome Yeast is used extensively for bread. In fact, nothing else has been found to be so efficient. There is, however, an objection to its use—generation of gas takes place slowly. The frequent necessity of having bread "raised" quickly has caused the introduction of chemical agents.

The two essential constituents of a baking powder are: (1.) A carbonate, which contains the carbonic acid gas in chemical combination. (2.) An acid constituent, which, when mixed with the carbonate and brought into solution with water, liberates the gas. Sodium bi-carbonate or "baking soda" is almost exclusively used for the first constituent. There is a variety of acid constituents.

These compounds do not act upon each other readily when mixed together in the solid state, but when brought into solution with water, chemical action takes place readily, and carbonic acid gas is liberated. The solid products of the chemical action are not removed by baking, as some manufacturers would have us believe, but remain in the bread and are eaten with it.

*NOTE.—In the preparation of this bulletin we desire to acknowledge the use of much valuable information taken from Bulletin 13, part 5, United States Department of Agriculture, Division of Chemistry.

Sour milk is very commonly used with "baking soda" for leavening bread. In this operation the lactic acid of the sour milk constitutes the acid ingredient. The same kind of chemical action takes place when baking powders are used as when sour milk is made use of.

Classification of Baking Powders.

Baking powders may be classified according to the nature of their acid ingredients. The three principal kinds are recognized as follows:

(1.) Tartrate powders, in which the acid constituent is tartaric acid in some form.

(2.) Phosphate powders, in which the acid constituent is phosphoric acid.

(3) Alum powders, in which the acid constituent is furnished by the sulphuric acid contained in some form of alum salt.

All powders sold at present will come under some one of these heads, although there are many powders which are mixtures of at least two different classes.

Tartrate Powders.—The form in which tartrate acid is almost exclusively used in this class is bi-tartrate of potassium or "cream of tartar." Bi-tartrate, or acid tartrate of potassium contains one atom of replaceable hydrogen, which gives it the acidity that acts upon the carbonate. The reaction takes place according to the following equation:

$$\underset{\text{Potassium bi-tartrate}}{KHC_4H_4O_6} + \underset{\text{Sodium bicarbonate}}{NaHCO_3} = \underset{\text{Potassium sodium tartrate}}{KNaC_4H_4O_6} + \underset{\text{Carbonic acid gas}}{CO_2} + \underset{\text{Water}}{H_2O}$$

From the above reaction it will be seen that the residue left from the use of a tartrate powder is a double tartrate of potassium and sodium. This compound is ordinarily called Rochelle salt, and is the compound formed when the two component parts of a seidlitz powder are moistened and mixed. A loaf of bread made from one quart of flour using a tartrate powder contains about one-third more crystallized Rochelle salt than is contained in one seidlitz powder. The character of this residue is probably the least objectionable of any of those left by baking powders. Rochelle salt is used as a mild purgative.

Phosphate Powders.—The salt commonly used to furnish the phosphoric acid in this class is mono-calcium phosphate $CaH_4(PO_4)_2$ or acid phosphate of lime. This compund in a more or less pure state is sold as a fertilizer. It is purified, however, for use in baking powders, but the gypsum which is formed in its production is difficult to remove, hence most phosphate powders contain considerable quantities of this impurity.

The following equation represents fairly well the action between moro-calcium phosphate and bi-carbonate of soda:

$$\underset{\text{Mono-Calcium Phosphate}}{CaH_4(PO_4)_2} + 2\underset{\text{Bicarbonate of Soda}}{NaHCO_3} = \underset{\text{di-Calcium Phosphate}}{CaHPO_4} + \underset{\text{di-Sodium Phosphate}}{Na_2HPO_4} + 2\underset{\text{Carbonic acid Gas}}{CO_2} + 2\underset{\text{Water}}{H_2O}$$

The residue remaining in the bread from the above reaction consists of di-calcium phosphate and di-sodium phosphate. Taking into consideration the fact that these compounds take up water of crystalization and weigh more than is represented in the equation, we find that the quantity of chemicals left in the dough is fully equal in weight to the amount of baking powder used. As to the nature of this residue it would seem to be about as unobjectionable as the residue from the tartrate powders. Disodium phosphate is a mild purgative, in doses of from one to two ounces. The action of di-calcium phosphate is not well understood.

Alum Powders.—In this class of powders the acid constituent necessary for the liberation of carbonic acid gas is furnished by one of the general class of compounds, known as alums. The alums are composed of a double sulphate of aluminum and an alkali metal. When used in a baking powder the aluminum is left as the hydroxide, while the sulphuric acid, thereby liberated, goes to set free the carbonic acid gas in the bicarbonate of soda. The alum of commerce is either potash alum or ammonia alum, the one or the other preponderating according to their relative cheapness.

The following shows the reaction taking place in a baking powder, made with burnt ammonia alum, *i. e.*: ammonia alum, from which the water of crystalization has been driven by heat:

$$\underset{\text{Burnt Ammonia Alum}}{(NH_4)_2Al_2(SO_4)_4} + 6\underset{\text{Bicarbonate of Soda}}{NaHCO_3} = \underset{\text{Hydrate of Aluminum}}{Al_2(OH)_6} + 3\underset{\text{Sulphate of Soda}}{Na_2SO_4} + \underset{\text{Sulphate of Ammonia}}{(NH_4)_2SO_4} + \underset{\text{Carbonic acid Gas}}{CO_2}$$

If potash alum were used the reaction would be precisely the same with the substitution of potassium for ammonium, whenever it occurs in the equation.

Reference to the above equation will show that the residue consists of sulphate of soda, sulphate of ammonia, and hydroxide of aluminum, and is therefore more complicated than those previously discussed. Sulphate of soda and sulphate of ammonia seem to have no marked effect on the digestion. The residue of aluminum hydroxide is insoluble in water, but deserves special mention It constitutes about 16 % of the total quantity of chemicals used. With reference to the effect of alum, Dr. Danglish* has said: "Its effect on the system is that of an astringent, producing constipation and deranging the process of absorption." The influence of alum on health, in the quantities in which it is usually added to bread, is still an open question with scientists. The residue is soluble in the juices of the body, and is thus absorbed by it, a fact which many manufacturers deny. The use of alum in bread-making is prohibited in countries having food adulteration laws. Unfortunately, lack of agreement among in-

*Hassall's Food, its adulterations and methods for their detection.

vestigators has prevented positive conclusions as to the harmfulness or heartlessness of the alum residue. The use of alum in baking powders is questionable, therefore. It is not too much to ask, therefore, that customers be given the opportunity of knowing when they use baking powders made from alum.

Alum and Phosphate Powders.—Some powders are met with which have been made up with various proportions of different acid ingredients, and which belong, therefore, to more than one of the above mentioned classes. The most common of these combinations is the 'alum phosphate mixture." The following equation represents the chemical change which takes place:

$$\underset{\text{Ammonia Alum}}{(NH_4)_2Al_2(SO_4)_4} + \underset{\text{Acid phosphate of Lime.}}{CaH_4(PO_4)_2} + 4\,\underset{\text{Bicarbonate of Soda.}}{NaHCO_3} = \underset{\text{Phosphate of Aluminum.}}{Al_2(PO_4)_2} +$$

$$\underset{\text{Sulphate of Calcium.}}{CaSO_4} + \underset{\text{Sulphate of Ammonia.}}{(NH_4)_2SO_4} + 2\,\underset{\text{Sulphate of Soda.}}{Na_2SO_4} + 4\,\underset{\text{Carbonic Acid Gas.}}{CO_2} + 4\,\underset{\text{Water.}}{H_2O}$$

It will be seen that the aluminium contained in this residue is held as phosphate of aluminium, which is about as soluble in the juices of the body as the aluminium hydroxide residue from the straight alum powders. Sulphate of lime, being deficiently soluble, is not absorbed to any appreciable extent by the body Sulphate of soda, and sulphate of ammonia have already been discussed.

Collection of Samples.

Samples for analysis were bought from dealers in Raleigh, Statesville, Durham, Henderson and Wilmington. In collecting samples our object has been to obtain the most common brands on sale in the State.

Methods of Analysis.

Our work has been directed toward determining the strength of the powders, or their yield in carbonic acid gas, and their composition, so far as to indicate the class to which each belongs. The amount of starch, or other legitimate filling, therefore, was not considered. The methods used were those used by the United States Department of Agriculture, Division of Chemistry, Bulletin 13, Part Fifth.

Results of Analysis.

The following tables give the results of our analyses:

I. Tartrate Powders

LABORATORY NUMBER.	BRAND.	NAME AND ADDRESS OF MANUFACTURER.	PLACE PURCHASED.	CARBONIC ACID GAS PER CT.
1063	Royal	Royal Baking Powder Co., N. Y.	Statesville . .	10 55
1078	Cream	Price Baking Powder Co , N. Y	Raleigh. . . .	12 06

II. Alum Powders.

LABORATORY NUMBER.	BRAND.	NAME AND ADDRESS OF MANUFACTURER.	PLACE PURCHASED.	CARBONIC ACID GAS PER CT.
1064	Good Luck..	Southern Mfg. Co., Richmond, Va.	Statesville..	16.04
1075	Magnolia Pepsin.	Magnolia Mfg. Co., Petersburg, Va.	Raleigh....	11.19
1076	Parrot and Monkey.	The Sea Gull Specialty Co., Baltimore, Md.	Raleigh....	13.90
1077	Good Luck...	Southern Mfg. Co., Richmond, Va.	Raleigh....	15.41
1079	Free Silver...	Roanoke Chemical Co., Roanoke, Va.	Raleigh. ...	14.32
1163	Success.....	Morehouse Mfg. Co., Savannah, Ga.	Durham ...	16.40
1166	Bob White...	Miami Mfg. Co., 150 Reade Street, New York.	Durham ...	6.34
1167	Free Coinage.	Manufactured for J. M. Gray, Washington, N. C.	Durham ..	6.93
1169	Possum	Savannah Soda Co., Savannah, Ga	Durham ...	9.79
1197	Blue Ribbon.	Blue Ribbon Baking Powder Co., Richmond, Va.	Henderson.	13.83
1200	Safety	Ballard and Ballard Co., Louisville, Ky.	Henderson..	9.61
1211	Campbell's.	The Potter, Porlin Co., New York.	Charlotte..	10.34
1264	Rising Sun.	Goldsboro Chemical Co., Goldsboro, N. C.	Wilmington.	13.65
1263	Railroad.	Morehouse Mfg. Co., Savannah, Ga.	Wilmington.	12.46

III. Phosphate Powders.

1164	Rumford ...	Rumford Chemical Works, Providence, R. I.	Durham ...	10.46
1201	Horsford ...	Rumford Chemical Works, Providence, R. I.	Henderson..	* 8.45

*In this powder the two ingredients are put up in separate packages. The percentage given is calculated upon the combined weight of the two packages.

IV. Alum and Phosphate Powders.

1062	Ro'an.....	Smith, Harpel & Co., Balt., Md .	Statesville..	2.62
1165	Old Dominion	Old Dominion Mfg Co., Richmond	Durham ...	11.23
1168	Rex	J. D. and R. S. Christian Co.. Richmond Va.	Durham.....	10.86
1199	Purity	Patapsco Baking Powder Co , Baltimore, Md.	Henderson	0.22
1209	One Spoon..	Taylor Mfg Co., New York.	Charlotte...	12.93
1210	Davis O. K..	R. B. Davis, 90 West Broadway, New York.	Charlotte ...	3.83

V. Tartrate Powder Containing Small Quantity of Alum.

1198	Home.	Home Baking Powder Co., Charlottesville, Va.	Henderson.	0 075

Conclusions.

It is evident that the percentage of carbonic acid gas in a baking powder would vary more or less according to the time elapsing between its manufacture and analysis. This is shown by the analysis of the same brand obtained at different places. On account of this deterioration it is very important that the baking powders should be fresh, in order to get the best results.

It is a noticeable fact, however, that 56 per cent. of the samples examined were straight alum powders, while 81 per cent. contained alum. As previously stated, the use of alum in baking powders is questionable, at any rate it should not be present in a baking powder unless the fact is plainly stated on the package.

Numbers 1198 and 1199 deserve special mention. It will be noticed from the tables that these powders contained only a trace of the essential constituent of a baking powder. In fact they would be absolutely worthless in bread making. No dates were found on the packages, and each appeared to be very old. It is very probable that the absence of carbonic acid gas was due to the age of the powders.

Recommendations.

Our investigations show the great necessity of adopting some method for the regulation of the sale of baking powders.

The following extract in regard to the subject is taken from Bulletin 13, Part Fifth, United States Department of Agriculture, Division of Chemistry: "The best plan for the regulation by law of the sale of baking powders in the present condition of our knowledge of their effect upon the system, would seem to be to require the manufacturer to use a label giving approximately the composition or analysis of the powder sold. The testimony that has been adduced is hardly sufficient to justify prohibition of the sale of the cheaper kinds of powders as being injurious to health, but if they were required to be sold with a label, giving their true composition, it would soon lead to investigations upon this point. * * * It is manifestly unjust to the public to allow the sale of a first-class tartrate powder and an alum powder as the same article, and it is equally unjust to the manufacturer of the high-priced article. The nature of the substance is such that the purchaser has no means of ascertaining by any simple or easy means the character of the article he buys, to say nothing of its relative quality. Such a regulation would meet with the approbation of all concerned in the manufacture of baking powders. The manufacturer of high grade powders, such as tartrate or phosphate powders, would certainly not object to it, and it would ultimately be to the advantage also of the cheaper sorts, such as alum powders, provided they could succeed in proving that such powders produced little or no injury to the health of the consumer."